# SCIENCE FOR GLASS PRODUCTION

UDC 666.1.031:003.1(047)

## POWER SAVING IN GLASS MELTING

**G. M. Matveev,[1] V. V. Mironov,[1] E. M. Raskina,[1] and K. E. Tarasevich[1]**

Translated from Steklo i Keramika, No. 11, pp. 10 – 11, November, 1998.

Pathways and methods of reducing power consumption during glass melting are discussed. The optimized parameters thus obtained are presented.

The glass industry is distinguished by high power consumption. In sheet glass production, fuel is mostly consumed by regenerative tank glass-melting furnaces. Their efficiency does not exceed 30%. The highest heat losses in tank furnaces are accounted for by waste gases from regeneration, the melting area enclosure, and heat radiation through apertures.

In order to reduce the heat losses through waste combustion products, waste recovery boilers producing saturated or overheated steam are installed next to the air regenerators.

For the purpose of reducing heat losses through the melting zone brickwork, special design and materials have been developed for heat insulation of the open outer surfaces of the furnace. Heat insulation of the furnace roof, bottom, and lateral surface that is not equipped with forced air cooling, account for significant saving in fuel. All apertures in the furnace should be closed, where possible.

Glass melting can be purely electric, combined, or include electric heating. Existing electric furnaces have varying capacity (from a few kilogram to 200 kg/day of glass). Combined glass melting includes heating of glass batch with flame and electric heating of the melt. Additional electric heating can be used in a traditional furnace heated by gas or liquid fuel to improve furnace efficiency and to ensure glass melt homogeneity.

Intensification of the melting process and increase in specific yield of glass melt reduce fuel consumption.

A sharp decrease in the consumption of boiler-and-furnace fuel per product unit can be expected only after the currently constructed float lines equipped with furnaces whose efficiency is 600 – 700 tons of glass melt per day are put into operation and, accordingly, the majority of worn and morally obsolete glass-making systems are removed from service.

A change in the design of existing furnaces intended to decrease power consumption can often be combined with activities intended to reduce harmful emissions. Control of the combustion process and selection of the type of burners and their locations can decrease the power consumption and simultaneously reduce the emissions of nitric oxides and dust into the atmosphere. In the last decades, manufacturers abroad succeeded in reducing the harmful emissions by 50 – 70% using relatively inexpensive measures which at the same time save 2 – 5% of power consumption. The analysis of the thermal model of the furnaces showed that the energy-saving measures should include restriction of batch moisture, preliminary preheating of the batch, air tightness of the flame space, decreasing foam formation, and introduction of increased amounts of glass cullet.

The new power-efficient technologies above all provide for a decrease in heat losses through the combustion products. One of such methods consists in decreasing the volume of combustion products by using pure oxygen for fuel combustion. Another method consists in the use of enthalpy (heat content) of the combustion products to heat the traditional batch or cullet, or to preheat the granulated batch. The same purpose can be accomplished by using a mixture of natural gas with water steam, making it possible to obtain high-calorie preheated (reformed) gas.

Important aspects of effective implementation of new power-efficient technologies include new refractory materials which make it possible to burn fuel in oxygen inside the furnace, and instruments which can monitor glass quality directly in the melt or determine the composition of combustion products beyond the furnace.

In the last 30 years, the power consumption per unit of net product in glassmaking in the West European countries decreased at least by 50%. The service life of the furnaces increased from 2 – 4 to 8 – 10 years for packaging glass, to 6 – 7 years for household glass, and to more than 10 years for float glass furnaces.

The governments of these states require a further decrease in the power consumption by 20% compared to the 1989 level. In the Netherlands, for instance, this goal is expected to be accomplished by year 2000.

Power consumption is usually determined as total amount of primary power consumed. Thus, 9 MJ of primary

[1] Center for Information and Economic Studies of the Construction Industry (VNIIÉSM).



0361-7610/98/1112-0338$20.00 

power account for 1 kW · h of electric heating (the efficiency of the power station is 40%).

Some examples of heat consumption per product unit for existing furnaces are given below:

a furnace for packaging glass, output 250 – 300 tons/day using 25% cullet: 4200 – 5000 kJ/kg;

a furnace for green glass with 90% cullet: 3750 – 4000 kJ/kg;

a float line, output over 500 tons/day using 25% cullet: 5000 – 7000 kJ/kg.

The lower limit of specific heat consumption can be achieved by implementing the following activities:

heat insulation of furnaces;

use of batches with a high content of glass cullet;

decrease in the batch moisture;

decrease in the coefficient of combustion air rate (to 1.05 – 1.08);

air-tightness of the furnace (prevention of cold air penetration);

decrease in the formation of foam on the glass melt surface through electric heating;

use of luminous flame (decrease in the heat consumption by 3 – 4%);

use of a roof with high radiating capacity (decrease in the heat consumption by 2 – 3%);

maximum use of furnace capacity;

prevention of overload.

In the last six years, 60 furnaces abroad were converted to full or partial oxygen heating (or were specially designed for oxygen heating). This method has been tested for several decades. The greatest number of experiments were carried out in the USA. In the Netherlands, a packaging glass furnace with the capacity of 200 tons/day and a furnace for electric engineering glass with a capacity of 60 – 70 tons/day have been operating on oxygen since 1994. The plans for 1995 – 1996 provided for conversion of five furnaces in Germany and the Netherlands to oxygen heating. The use of pure oxygen instead of air in fuel combustion produces a decrease in the content of the nitric oxide in the furnace (and, consequently, in the waste gases) down to 3 – 7%. Moreover, the amount of combustion products is lowered by a factor of 4 – 6; therefore, 70% of the heat remains in the furnace tank and only 25 – 30% is removed with the combustion products. 55 – 60% of the combustion product heat in a regenerative tank furnace and 55 – 60% in a recuperative furnace is used to heat the air.

Furnaces in which 100% of fuel is burned in oxygen are compact and have smaller sizes than regenerative furnaces. The absence of regenerators provides for lower heat losses through the brickwork surface. The consumption of thermal power in this case decreases by 5 – 10% in a regenerative tank furnace with horseshoe-shaped flame, and by 25 – 30% in a recuperative furnace.

Since 0.425 kW · h (or 3.8 MJ) of primary power is required to obtain 1 $m^3$ of oxygen, the melting of glass with fuel burning in oxygen is less efficient than ordinary melting in a regenerative furnace, but is 20 – 25% more effective than melting in a recuperative furnace. The heat of combustion products in the case where oxygen is used can be utilized to heat the batch or in a thermomechanical recuperator.

When the fuel is burned in oxygen, the concentration of nitric and sulfur oxides in the combustion products is higher than in usual combustion in regenerative and recuperative furnaces; however, the total emission of the furnace gas into the atmosphere is significantly lower, since the combustion proceeds without participation of air whose content of nitrogen is 78%.

The average time the combustion products spend in the furnace space is 7 – 12 sec for the regenerative and recuperative furnace and 25 – 30 sec for the case of oxygen combustion.

The resulting power consumption significantly depends on the air-tightness and insulation of the furnace, its design, and arrangement of the burners. The efficiency increases if the combustion products are removed along the cold batch. The low temperature of the combustion products after their exit from the regenerator or the recuperator and the low content of nitrogen and oxygen provide for high thermal efficiency of the furnace operation. The type of burner primarily affects the formation of nitric oxides. As a whole, the burner type has an insignificant effect on thermal efficiency. However, the type of burners and their location are very important for reducing the dust emissions.

It was established that the temperature of the furnace roof decreases by 30 K when oxygen was used in combustion, compared to the traditional heating, with thermal loads being equal. The formation of foam on the glass melt surface does nor affect the roof temperature.

A high velocity of gases immediately above the glass melt surface, a reducing medium, too hot flame and overheated sites on the glass melt surface all contribute to excessive volatility and an increase in the dust emission. Burners with long and relatively cold flames decrease the dust emissions.

A high content of sodium vapor can result in increased corrosion of the dinas roof in its cold areas, therefore, the roof should be thoroughly insulated.

A high concentration of water steam in the combustion products when oxygen is used for glass melting leads to a higher (by 30 – 60%) content of OH groups in the glass melt compared to the traditional melting. The obtained glass has lower viscosity and high infrared absorption in the range of 2.5 – 4.5 μm. The fuel combustion in oxygen reduces as well the oxygen activity in the melt.

The methods for further improvement of glass melting with the use of oxygen are as follows:

development of new furnace designs with optimum heat transfer between the combustion products and the glass melt or the batch.

use of combustion products to heat the batch or to obtain reformed gas;

use of new refractory materials or modification of the design of the upper part of the furnace for the purpose of ensuring resistance to vapors of alkali metals.

It is expedient to take into account the above data for the design of new furnaces and for reconstruction and operation of existing furnaces.